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CALCULATION OF THE EFFECT OF BREAKDOWN ON MACHINE-TOOL LINE

The experience of using automatic machine transfer lines has shown that the basic and most important requirement of machine tools and combination machine tools is their reliability. Lack of reliability, such as unplanned and emergency stops and stops due to accidents, brings the value of the huge possible advantages of an automatic machine transfer line to nothing.

The more drawn-out the automatic transfer line, the more machine tools and other combination machine tools included in it, the more possible it is that at any moment one of them will break down, thus interrupting the operation of the entire line.

Determining the quantitative relationship between the index of reliability of separate combinations of the automatic transfer line, the time of their useful work, and the total extent of the line has exceptional importance. The establishment of such a quantitative relationship will aid further work in improving and increasing reliability of machine tools and tools, as well as electric, hydraulic, and pneumatic devices with which modern machine transfer lines are equipped. The utilization of this quantitative relationship permits selection of the optimum arrangement of an automatic line for specific conditions.

The operating time of any one machine tool included in an automatic machine transfer line can be divided into three parts:

1. Machine-tool operation -- that part of the line including the machine-tool itself and its related clamping, transfer, and similar devices.

2. Machine-tool standstill due to its own breakdown.

3. Machine-tool standstill due to breakdown of other machine tools in the line.

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The following symbols will be used: q_n -- relative time of effective machine-tool operation; r_n -- relative time of machine-tool standstill due to its own breakdown; p_n -- relative time of machine-tool standstill due to its own breakdown as well as that of other machine tools; and n -- total number of machine tools in an automatic transfer line.

Thus: $p_n + q_n = 1$ (1)

Assuming that all machine tools are equally subjected to breakdowns, it can be taken for granted that the standstill of the automatic line on an average over a very long time, will occur for machine tools. For this reason, the relative time r_n of machine-tool standstill is due to the breakdown of the machine-tool in question n times less than the total standstill time (it is assumed that if the standstill is caused by breakdowns on several machine tools simultaneously, then the duration of the standstill will increase in proportion to the number of machine tools being repaired):

$$r_n = \frac{p_n}{n} \tag{2}$$

The cause of the standstill can arise only during the time of line operation. Consequently, the average number of standstills under identical operating conditions is proportional to the time of line operation. From here it is easy to conclude that the standstill time due to breakdowns on the given machine tools is also proportional to the time of its actual operation.

Thus, it can be emphasized that the relation of the time of effective work of the machine tool to the time of standstill due to breakdowns on the specified machine tools does not depend on the number of machine tools n in the line. This relationship will be represented by the symbol s, that is,

$$s = \frac{q_n}{r_n} \tag{3}$$

This is the special characteristic of reliability of continuous operation of machine-tool lines.

Taking the equations (1), (2) and (3), the relationship q_n is reached:

$$q_n = \frac{s}{n+s} \tag{4}$$

i.e., the function between the relative time of effective operation of the machine tool q_n and the total number of machine tools in the automatic machine transfer line.

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